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Research-based learning in a transversal Entrepreneurship and Innovation undergraduate course

Maria Helen Camacho [a,b], Katherine Chiluiza [c] and Martin Valcke [b]

[a]Escuela Superior Politécnica del Litoral (ESPOL), Facultad de Ciencias Sociales y Humanísticas, Guayaquil, Ecuador; [b]Department of Educational Studies, Ghent University, Ghent, Belgium; [c]Escuela Superior Politécnica del Litoral, Facultad de Ingeniería en Electricidad y Computación, Guayaquil, Ecuador

ABSTRACT

The present article reports an empirical quantitative study involving 107 undergraduate students from Entrepreneurship and Innovation courses in a public university. Students were randomly assigned to 3 conditions: structured Research-based learning (RBL), semi structured RBL and control. We hypothesized that studying in a structured RBL condition would result in a higher intention to do research (INT) and higher course achievement (CA) along with positive changes in autonomous motivation (AM), perceived behavioral control (PBC), behavioral beliefs (BB) and subjective norm (SN); as compared to studying in a semi-structured RBL and control condition. The intervention lasted 7 weeks as part of a regular course and was based on Brew's RBL framework. A significant differential impact was observed in overall course achievement and in specific research skills clusters. No significant differences were observed in INT, AM, PBC, BB and SN. The results lead to clear implications and directions for future research.

KEYWORDS

Research-based learning; RBL framework; research skills; intention to do research; course achievement

Introduction

The idea of integrating teaching and research – labeled as Teaching-Research Nexus (TRN) – has become central to university curricula around the world (Tight 2016). Research acknowledges the benefits of involving students in research to promote learning (Corwin, Graham, and Dolan 2015; Soltano, Meyer, and Larrivee 2016). However, research also reports a lack of practical approaches to TRN (Brew 2010).

Research-Based Learning (RBL) has been put forward as a potential TRN methodology (Schlicht and Klauser 2014) which involves students in actual research (Jones 2011).

Available empirical evidence, mostly from engineering and science courses, shows how RBL promotes student research skills (Wilson et al. 2013; Tomasik et al. 2013; Chase, Pakhira, and Stains 2013), intentions to do research (Shaw and Kennepohl 2013; Baiduc et al. 2017; Firdaus and Darmadi 2017), research motivation (Bahr 2009) and research self-efficacy (Chase, Pakhira, and Stains 2013). However, few authors have reported RBL implementations in undergraduate academic disciplines such as Entrepreneurship (Guerin and Ranasinghe 2010; Pittaway 2009). The present study addresses this gap in the literature, by focusing on RBL in an 'Entrepreneurship and Innovation' course.

CONTACT Maria Helen Camacho mariahelen.camachorivadeneira@ugent.be Escuela Superior Politécnica del Litoral (ESPOL), Facultad de Ciencias Sociales y Humanísticas, Campus Gustavo Galindo km 30.5 Vía Perimetral P.O. Box 09-01-5863. Guayaquil, Ecuador

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Theoretical background

The nature of research-based learning

TRN is central to the Humboldt definition of a research-oriented university (Sam and van der Sijde 2014) and implies opportunities for doing research (Söderlind and Magnell 2015). Different TRN frameworks can be found in the literature. For instance, Griffiths (2004) describes three ways of engaging students in research by either focusing on the subject content (research-led), research processes (research-oriented), or inquiry activities (research-based learning). Healey and Jenkins (2009) define a fourth way, emphasizing the discussion of scientific material (research-tutored). Similarly, Levy and Petrulis (2012) stress an additional focus on students developing existing ideas or discovering new ones. These variations suggest different ways and levels of engagement in the research cycle (Jenkins and Healey 2010).

Brew (2013) presents a more operational approach and develops a comprehensive RBL 'curriculum wheel,' explaining decision-making about (1) the study context, characteristics of students, learning outcomes, abilities to be focused upon, type of instructional tasks and evaluation processes and (2) whether these decisions are made by teachers, decided by students or negotiated between them. The latter shows how RBL varies in the level of student autonomy in carrying out research. Brew's curriculum wheel is adopted in our study to operationalize the RBL-approach. Of importance in the context of this study is that RBL can as such be highly structured or less structured when presented to students.

RBL benefits

Previous studies suggest RBL improves students' research skills (McNamara 2016), and interest in pursuing future research degrees (Brownell, Kloser, and Fukami 2012; Guerin and Ranasinghe 2010), a stronger study commitment, conception of science and stronger communication skills (Willis, Krueger, and Kendrick 2013), gives a boost to their learning process, knowledge acquisition, and development of cognitive thinking skills (Sota and Peltzer 2017).

Healey (2005) claims that undergraduate students could get benefits in their subject learning when engaged in inquiry activities. Similar studies demonstrate that inserting research skills develops students' knowledge production (Walkington et al. 2011) and improve subject-related competences (Lambert 2009). Alvarado and Spring (2018) state that RBL might increase retention and develop a scientific character. Furthermore, RBL helps students to contribute to faculty research productivity when integrated in academic activities (Horta, Dautel, and Veloso 2012), generates subject motivation, and develop understanding of research methods (Fuller, Mellor, and Entwistle 2014).

Defining an RBL research model

To explain the impact of RBL on the variables listed above, we build on a number of theoretical frameworks that link RBL-implementations to dependent and interaction variables.

Firstly, we build on Brew (2013) to define the nature of RBL (see Appendix Table B) and to distinguish a structured and semi-structured version of RBL. This mirrors the different levels of control in her Curriculum Wheel. Students involved in RBL settings are reported to attain higher grades (Tomasik et al. 2013) and learning performance (Follmer et al. 2015); hence repositioning learning content in a significantly different way (Schneider and Preckel 2017).

Next, we build on the Theory of Planned Behavior (Ajzen 1985), to look at precursors of the dependent variables: Intentions to do research (INT) and Course Achievement (CA). TPB defines three precursors to INT and future behavior:

(a) Perceived Behavioral Control (PBC) – often operationalized as self-efficacy - refers to people's awareness of how simple or complex it may be to perform a specific behavior (Ajzen 1991). Bandura (1997) defines self-efficacy as a belief about one's own ability, in this case, research

activities. RBL is expected to boost student confidence to conduct research (Jones 2011; John and Creighton 2011; Joubert, Hebel, and McNeill 2017).

(b) Behavioral Beliefs (BB) refer to someone's opinions about a specific behavior (Ajzen 1991); such as being involved in research. RBL studies report an increase in students' attitudes towards research (Chang and Ramnanan 2015; Wiley and Stover 2014; Ryan 2016; Colbert-White and Simpson 2017).

(c) Subjective Norm (SN) refers to normative assumptions of others in a student context which invoke a feeling of being connected to them (Hill, Mann, and Wearing 1995). RBL research reports how students feel stimulated to present their research to others (Cole et al. 2013), get feedback from faculty (Follmer et al. 2015) and even perceive gains in shared competences (Tomasik et al. 2014).

Thirdly, we build on Self-Determination Theory (SDT) to identify the impact and role of student motivation in RBL settings (Ryan and Deci 2000). SDT stresses how Autonomous Motivation (AM) is enhanced and promotes willingness to be involved in behaviors when key psychological needs have been satisfied. RBL is as such expected to increase students' need for 'Autonomy' because they get opportunities to carry out actual research. Next, they are boosted in their 'Competence' because they are able to achieve complex tasks. Lastly, they are improved in their 'Belonging' due to the collaborative setting in which they set up research (McCarthy 2015; Wood 2016).

The above theoretical and empirical base helps developing the following research model. Figure 1 emphasizes how the impact of RBL affects variables in a direct and indirect way.

Materials and methods

A quasi-experimental pretest–posttest design was set up studying the differential impact of three alternative implementations of the 'Entrepreneurship and Innovation' course.

Hypotheses

H1: Studying in a structured RBL condition will result in higher Intentions to do research and Course Achievement (CA) as compared to studying in a semi-structured RBL or control condition.

H2: Studying in a structured RBL condition will result in higher positive changes in AM, PBC, BB and SN as compared to studying in a semi-structured RBL or control condition.

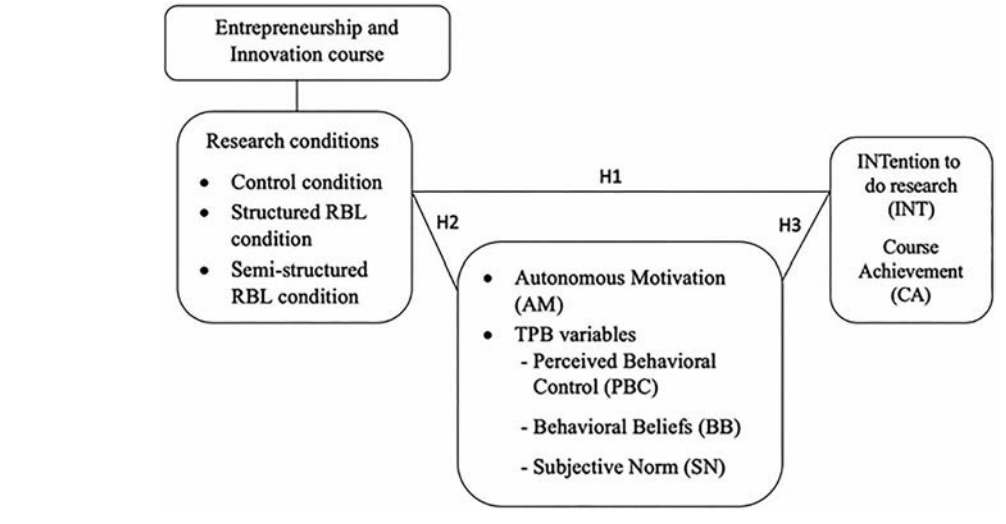

Figure 1. Theoretical model linking RBL to specific student variables.

H3: Changes in AM, PBC, BB and SN will interact with the impact of studying in a structured RBL, semi-structured RBL or control condition on Intentions to do research and CA.

Context of the study and sample

Entrepreneurship and Innovation is a transversal undergraduate course offered at the top public university where our research study took place. It is mandatory for all students to enroll in this course once they have completed about half of their total degree credits. The aim of this course is to help students develop general business skills which they may later apply in their specific study fields. It combines practical approaches where students follow the entrepreneurial cycle towards the creation of their own services or products.

Undergraduate students enrolled in this course ($N = 118$) were the participants in our study. For research purposes 4 parallel classes taught by 2 different teachers were selected. Two classes were randomly assigned to the control condition, and the other two classes to the experimental or Research-Based Learning condition: one to the structured RBL and one to the semi-structured RBL. Each teacher was in charge of an RBL and a control condition class. This helped controlling potential differences due to teaching styles.

Table 1 summarizes student characteristics. Due to individual circumstances, 11 students dropped out of the study, resulting in a full data set of 107 students.

All participant students signed an informed consent form. The study was approved by the educational authorities of the course coordinator and teachers.

Research instruments

Instruments were piloted in a study prior to the RBL intervention, involving students not included in this study (Appendix A). In addition, students were presented with a background questionnaire.

The Theory of Planned Behavior guidelines (Ajzen 1985, 1991) helped the development of the INT, SN and BB scales (5-point Likert). Below we report pretest reliability values and an example item.

The INT scale consisted of 10 items (pre-test $\alpha = 0.845$): 'As a student of the Entrepreneurship and Innovation course, I will be able to empathize with people by knowing their needs regarding a particular problem.'

The SN scale reflected 10-items ($\alpha = 0.742$): 'My classmates in the Entrepreneurship and Innovation course suggest that I brainstorm possible solutions to the problem and explain how to solve it.'

The BB scale contained 10 items ($\alpha = 0.810$): 'My ability to select and justify techniques that help me generate ideas or solutions to the problem will strengthen me as an Entrepreneurship and Innovation student.'

The PBC scale was built following Bandura's guidelines (2006) and contained 27-items ($\alpha = 0.968$): 'Rate your degree of confidence to define a problem based on the perceptions of people.'

To determine Autonomous Motivation (AM), we adopted seven items from the Intrinsic Motivation Inventory (Deci and Ryan 1982) and three from the Motivation at Work scale (Gagne et al. 2010), resulting in a 10 item AM-scale ($\alpha = 0.931$). Students were asked to indicate on a 7-point Likert scale their agreement with statements such as 'I enjoy doing research related activities very much in my Entrepreneurship and Innovation course.'

To determine Course Achievement (CA), we calculated scores for the 10 weekly course assignments.

Table 1. Student characteristics (*N* 107, *M* and SD).

Control group			Structured RBL			Semi-structured RBL		
Age	Male	Female	Age	Male	Female	Age	Male	Female
21.98 (2.27)	21	31	22.11 (2.28)	12	24	23.26 (3.51)	12	7

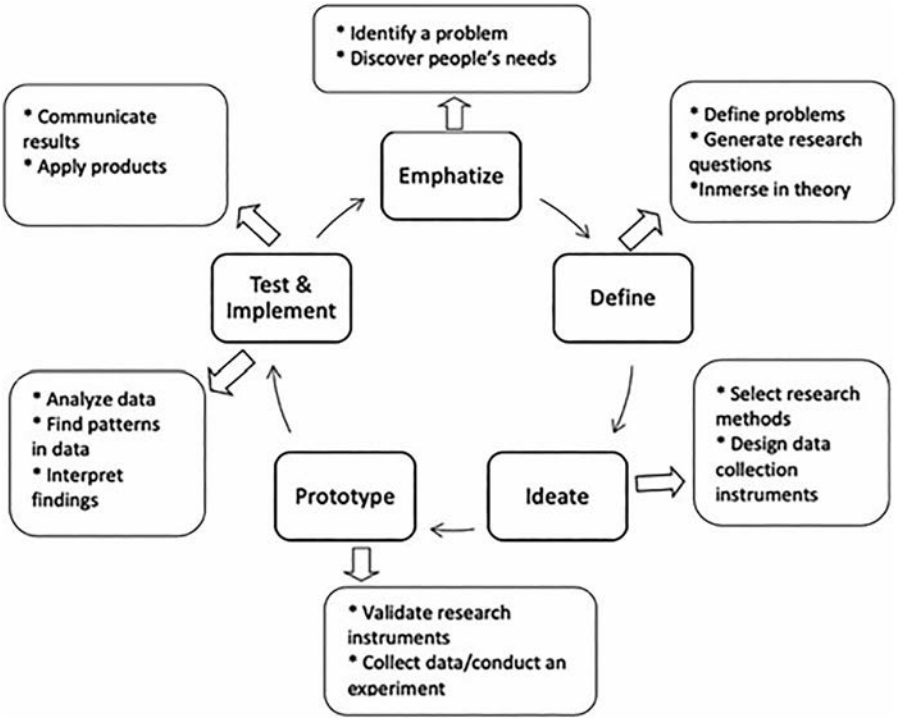

Figure 2. Research cycle linked to entrepreneurial cycle.

Nature of the RBL intervention

We set up RBL within an 'Entrepreneurship and Innovation' course. This implied linking the research cycle adapted from Jungmann and Ossenberg (2014) to the entrepreneurial cycle (Brush et al. 2003); as depicted in Figure 2 (see also Roach, 2017).

Students were requested to work on 10 weekly course assignments, to be submitted via an online learning management system. All students participated in some kind of research activity; meeting deontological concerns about equal opportunities.

The main difference between both RBL conditions depended on the proportion of research instruction, structure and guidance. This is described in detail in Appendix Table B (https://drive.google.com/file/d/1Gtgd08PE4LcVEKWA3y0nxTvcOV_Vunl0/view?usp=sharing).

The differences in the RBL implementation followed the RBL model of Brew (2013). For example, in cluster 1 (identify a research problem), RBL moves from a fixed design, where students do the task based only on material provided by the teacher to making their own decisions about existing researchable problems in the community. In cluster 2 (define a research problem), students make their own choices regarding existing problems inside and outside university. In cluster 3 (immerse in theory), the RBL design is shared as tasks are initially structured by the teacher and then students select what information to search and how to justify its relevance. The same applies to the assignments in relation to the other clusters. Appendix Table B exemplifies how research conditions reflect different levels in autonomy and specifications of instructional variables.

Procedure

The study was set up during the first semester of the academic year 2017–2018. Data was gathered during 9 weeks which included 2 weeks for pre and post-tests and 7 weeks for course assignments.

The background questionnaire and all scales were administered during regular class time, following a protocol. Administration took between 40 and 45 minutes.

Next, students followed their version of the course, considering the research condition during the subsequent 7 weeks. Teachers followed a detailed syllabus containing all materials and assignments. The overall setting involved students in a 'mini-business' to create a new product during an entrepreneurial cycle. By the end of the semester, students presented their business results and explained how every phase of the entrepreneurial cycle had been implemented.

Every week students turned in assignments that were graded individually by the researcher on the base of rubrics. The final assignment – the presentation of their business results – was evaluated by four external examiners on the base of a specific rubric that focused mainly on their communication skills (final stage of the entrepreneurial cycle).

After the intervention, all students filled out – during regular class time – the post-test version of the instruments.

Results

All analyses were carried out with SPSS® version 24. Next to the calculation of descriptives, hypotheses were tested on the base of analysis of (co)variance with research conditions as factors. Focusing on the dependent variable Course Achievement (CA) both a general achievement score was used in the analysis, next to cluster scores focusing on specific research competences.

Focusing on INTentions to do research (INT), a difference score was calculated between the pre- and posttest value. The same applies for the testing of H2 and H3 where difference scores were calculated for SN, BB, PBC and AM.

A significance level of $p < .05$ was put forward. Statistical assumptions were tested (homogeneity of variance, normal distribution) and Bonferroni correction was applied. In case of violation of assumptions, Tamhane's T2 was calculated. Effect sizes were calculated to interpret significant results (Cohen's *d*), considering guidelines of Baguley (2009).

Table 2 summarizes the descriptive results that reflect small differences between research conditions. Firstly, we observe a decrease over time in INTentions to do research and Autonomous Motivation in all conditions; though this is the least in the structured RBL condition. These students reflect a higher average in their perceived behavioral control (PBC) and behavioral beliefs (BB) while students in the semi-structured RBL condition reflect higher subjective norm scores. For each cluster in course achievement, we observe that structured RBL students outperform the students in other research conditions.

Table 2. Summary of descriptive results in relation to all research variables (*N*).

Variables	Structured RBL (*N* = 35)	Semi-structured RBL (*N* = 19)	Control (*N* = 52)
Change in Intention to do research[a]	−0.07 (0.86)	−0.18 (0.37)	−0.20 (0.58)
Change in AM[b]	−0.24 (0.96)	−0.34 (1.02)	−0.56 (1.02)
Change in PBC[a]	1.21 (9.75)	−1.18 (15.26)	1.08 (14.61)
Change in BB[a]	0.06 (0.66)	−0.07 (0.39)	−0.15 (0.56)
Change in SN [a]	0.06 (0.53)	0.16 (0.47)	−0.01 (0.59)
Course Achievement (overall)[c]	8.80 (1.31)	6.70 (2.43)	7.94 (1.89)
Course Achievement (clusters)[c]	8.89 (1.43)	5.97 (3.43)	6.84 (2.44)
Cluster 1	8.63 (2.35)	7.17 (3.33)	8.24 (1.97)
Cluster 2	8.77 (1.25)	6.30 (2.56)	7.53 (1.86)
Cluster 3	8.67 (2.71)	7.66 (3.56)	8.34 (2.86)
Cluster 4	8.84 (2.01)	5.98 (3.90)	8.79 (6.25)
Cluster 5	9.08 (1.09)	8.48 (0.97)	8.22 (1.48)
Cluster 6			

[a]Maximum score is 5.
[b]Maximum score is 7.
[c]Maximum score is 10.

Hypothesis 1

The analysis of variance results reveals no significant differences in INTention to do research ($F_{(2, 104)} = .448$, $p = .915$). However, the analysis results reflect significant differences between conditions in overall Course Achievement ($F_{(2, 104)} = 8.24$, $p = .001$, partial eta squared = .13). Post-hoc comparison results show that the mean score of students in the structured RBL condition ($M = 8.80$, SD = 1.31) significantly differs from the semi-structured RBL condition ($M = 6.70$, SD = 2.44). Cohen's $d = 0.89$ reflects a large effect size. Additionally, the structured RBL condition ($M = 8.80$, SD = 1.31) differs significantly from the control condition ($M = 7.94$, SD = 1.89). Cohen's $d = 0.40$ reflects a medium-size effect.

The analysis of variance per research skill cluster reveals significant differences between conditions in the following clusters: 1 (identify a research problem), 3 (immerse in theory) and 6 (communicate results). No significant differences between conditions were found in cluster 2 (define a research problem), 4 (design research instruments and collet data) and 5 (interpret findings).

Post-hoc comparison results indicate that the mean score for the structured RBL condition was significantly different in the following clusters 1 ($M = 8.89$, SD = 1.44), 3 ($M = 8.78$, SD = 1.25) compared to both semi-structured RBL ($M = 6.70$, SD = 2.43) and control condition ($M = 7.94$, SD = 1.89). However, in cluster 6, the structured RBL condition significantly only differs significantly ($M = 9.0833$, SD = 1.0987) from the control condition.

No statistically significant differences were observed in clusters 2 ($M = 8.63$, SD = 2.36), 4 ($M = 8.67$, SD = 2.71) and 5 ($M = 8.84$, SD = 2.01).

Hypothesis 2

The analysis of variance reveals no significant differences in Autonomous Motivation ($F_{(2, 104)} = 1.122$, $p = .330$), Perceived Behavioral Control ($F_{(2, 104)} = .240$, $p = .787$), Behavioral Beliefs ($F_{(2, 104)} = .266$, $p = .767$) and Subjective Norm ($F_{(2, 104)} = .755$, $p = .473$).

Hypothesis 3

Table 3 summarizes the analysis of covariance results. We again observe a non-significant differential impact of RBL on changes in Intention to do Research ($F_{(2, 97)} = .461$, $p = .632$). As could be expected, also no interaction effect is observed due to changes in the co-variables AM, PBC, SN except for BB.

Table 4 summarizes the analysis of covariance results when looking at overall and clustered Course Achievement. Only the main effect of the research condition seems to be significant in overall CA ($F_{(2, 97)} = 7.355$, $p = .001$). As discussed above, structured RBL students outperform those in the semi-structured RBL and control condition. No significant interaction effects related to changes in co-variables can be found.

Also, the main effect of research conditions seems to be significant in these clusters: identify a research problem ($F_{(2, 97)} = 10.62$, $p = .000$), immerse in theory ($F_{(2, 97)} = 10.03$, $p = .000$) and communicate results ($F_{(2, 97)} = 3.948$, $p = .022$). Only the latter shows a significant interaction effect related to changes in Autonomous Motivation.

Table 3. Analysis of covariance results with INTentions to do research as the dependent variable (*N* 108).

	F	Df
Condition	0.46	2
Change in AM	1.84	1
Change in PBC	1.84	1
Change in BB	62.06*	1
Change in SN	0.11	1

Note: *F* = ratio of 2 measures of variance; df = degrees of freedom.
*$p < .05$.

Discussion

Based on Brew's Curriculum Wheel (2013) two RBL implementations were developed within an 'Entrepreneurship and Innovation' course and compared to a control condition.

Contrary to expectations, studying in the different research conditions did not result in differences in students' intentions to do research. These non-significant findings may result from shared design characteristics in all three conditions. All Entrepreneurship and Innovation students had to develop a range of research competences (Brush et al. 2003); thus pushing them to conduct research in a smaller or larger extent. Research intentions were as such fostered in all conditions, given the course goals (Willison 2012).

Concerning Course Achievement, we distinguish between overall and research cluster achievement. Overall course achievement seems to differ between conditions. Higher achievement is observed in structured RBL compared to semi-structured RBL and control condition. As stated by Myatt (2012) undergraduate research experiences appear to be associated to students' higher knowledge gains and may contribute to academic performance (Howard and Miskowski 2005).

Similarly, significant differences between conditions are observed in 3 research clusters: identify research problems, immerse in theory and communicate research results. In the first two, students in the structured RBL condition outperform the other conditions whereas in the third, they excel only compared to students in the control condition.

We can explain our results by looking at the 'structure' in the research tasks. The fact that structured RBL significantly outperform semi-structured RBL and control students could be associated to the idea that learning through inquiry should be supported with sufficient guidance (Lehtinen and Viiri 2017). This is in consonance with Brew's (2013) curriculum 'wheel' approach with gradual changes in levels of autonomy and structure. Also, Kirschner, Sweller, and Clark (2006) along with Colbert-White and Simpson (2017) point out that unguided instruction is less effective compared to methodologies that emphasize clear structure and guidance.

Table 4. Analysis of covariance results with overall CA and Clustered CA as the dependent variable (*N* 108).

	F	Df
Condition	7.35**	2
Change in AM	3.30	1
Change in PBC	1.28	1
Change in BB	0.96	1
Change in SN	0.24	1
Identify a research problem		
Condition	10.62**	2
Change in AM	0.77	1
Change in PBC	3.53	1
Change in BB	1.43	1
Change in SN	0.10	1
Immerse in theory		
Condition	10.03**	2
Change in AM	0.05	1
Change in PBC	2.70	1
Change in BB	1.35	1
Change in SN	0.66	1
Communicate results		
Condition	3.94*	2
Change in AM	4.50*	1
Change in PBC	0.24	1
Change in BB	0.42	1
Change in SN	1.36	1

Note: *F* = ratio of 2 measures of variance; df = degrees of freedom.
*$p \leq .05$.
**$p \leq .01$.

Research activities are complex in nature and entail substantial efforts (De Jong 2010) leading to high cognitive loads (Sweller 2015). Little or no structure seems to invoke extraneous cognitive load that affects available cognitive resources to process information (Sweller, Van Merrienboer, and Paas 1998). This extraneous cognitive load was reduced in the structured RBL setting due to clearer direction (Sweller 2016), examples (Paas, Renkl, and Sweller 2004), less cognitive disruption (Schmeck et al. 2015) and a stronger focus on instructional design (Morrison, Dorn, and Guzdial 2014).

The non-significance differences found in 3 research skill clusters can be explained by their positioning in the course. Two of them appear towards the end. They include tasks that integrate earlier research competences, thus conducing to larger levels of complexity and cognitive demands to tackle them. This could have invoked in all students – irrespective of the research condition – a too high level of extraneous cognitive load. The tasks could have pushed their cognitive resources to their limits (Sweller 2011) preventing the transfer of earlier learning to novel contexts (Paas et al. 2003; Boula et al. 2017).

Also, the fact that most students lack prior knowledge linked to the course contents could have hindered the deployment of strategies in research tasks. As described by Bloom et al. (1956), individuals can successfully deal with new content when they can rely on prior knowledge. Early exposure to research might be less favorable in novice students due to deficiencies in their theoretical background (Ameen, Batool, and Naveed 2018). Therefore, novice students handling unfamiliar content need more guidance (Kirschner, Sweller, and Clark 2006).

Regarding our second hypothesis, we could not confirm that higher positive changes in Autonomous Motivation, Perceived Behavioral Control, Behavioral Beliefs and Subjective Norm would result from studying in a structured RBL condition compared to a semi-structured RBL or control condition. These findings contradict the assumption that conducting research increases students' self-confidence (Russell, Hancock, and McCullough 2017) and research practice appreciation (Myers et al. 2018).

As earlier displayed in Table 2, students in the 3 conditions reflect a progressive decrease in both intentions to do research and autonomous motivation. The latter shows students' low determination and involvement in research. This could be explained by the fact that students were demanded to submit assignments within short time periods and received evaluation rubrics primarily focused on scores rather than on explicit feedback. As explained by Deci and Ryan (2012) there are specific factors such as the burden of deadlines and the lack of encouraging feedback that may have put more pressure on students; thus depleting their autonomous motivation. Similarly, being confronted with obligatory research assignments plus most students' limited research knowledge may have affected their self-confidence to do research appropriately (Rosenkranz, Wang, and Hu 2015).

As can be expected from the results in relation to H2, the third hypothesis could not be confirmed. We could not demonstrate that changes in autonomous motivation, perceived behavioral control, behavioral beliefs and subjective norm interact with the impact of studying in a structured RBL, semi-structured RBL or control condition on students' intentions to do research and course achievement. The fact that students were not given opportunities to choose topics of their interest in relation to the assignments and mostly had to deal with imposed research activities, probably made them feel less autonomously motivated to dedicate time and effort to them. Also, the absence of detailed individual feedback could have undermined students' confidence in their own research skills (Niemiec and Richard 2009; Cortright et al. 2013) as they could not acknowledge to what extent they were progressing (Cheong, Reeve, and Moon 2012). This may explain the no significant effect of RBL on students' intention to do research and the no interaction with covariables.

In relation to overall course achievement, despite the significant impact of RBL on it; again, we could not observe any interaction with covariables. We may assume that some students developed research competences throughout the course due to continuous exposition to research tasks (Myatt 2012) and not because of pressures or expectations from others such as teachers or parents (Hagger et al. 2015; Popa and Voicu 2015) or a highlighted particular interest to learn (Cortright et al. 2015).

In clustered course achievement, we could only confirm changes in autonomous motivation interacting with the impact of RBL in relation to the cluster 'communicate results.' Since this cluster was positioned at the end of the course, students could have already assimilated research knowledge that enabled them to integrate what was required in the task. Also, the fact that this cluster involved the presentation of results from a mini-business project of students' own choice, could have given them sense of volition and willingness to achieve well; thus reflecting higher levels of autonomous motivation (Rosenkranz, Wang, and Hu 2015). As stated by Deci and Ryan (2000), when students are involved in class activities that provide them choice and autonomy, they perform better and their motivation boosts simply by the learning experience as such and no other factors.

Conclusions

Research-based learning was researched in this study as an operational implementation of TRN. The present study is a starting point for future RBL implementations. It presents a benchmark in terms of the design of RBL and the impact on variables in undergraduate students. Although we could not confirm all hypotheses, we found a significant differential effect of RBL on overall achievement and in some of research skill clusters. This is encouraging and opens avenues for future research that adopts mixed method designs and involves other undergraduate student populations. In this way, TRN contributes to the innovation of teaching and learning in undergraduate higher education.

Practical implications and further research

The findings of our research study have some implications. From a practical perspective, this study offers guidelines about how to link the entrepreneurial cycle to the research cycle when designing students' course assignments. Also, we develop an RBL implementation based on the wheel model proposed by Brew (2013) that can be replicated by other researchers in alternative academic disciplines. Our results suggest that research is definitely implied in all stages of the entrepreneurial cycle and this is why, students in all conditions somehow developed intentions to do research. Therefore, a mixed methods approach could be recommended in order to go beyond statistical measures and explore students' changing views and opinions.

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ORCID

Maria Helen Camacho http://orcid.org/0000-0003-1569-4263
Katherine Chiluiza http://orcid.org/0000-0001-5992-6236
Martin Valcke http://orcid.org/0000-0001-9544-4197

References

Ajzen, I. 1985. "Constructing a Theory of Planned Behavior Questionnaire." Retrieved February 7, 2016, from http://people.umass.edu/aizen/pdf/tpb.measurement.pdf.

Ajzen, I. 1991. "The Theory of Planned Behavior." *Organizational Behavior and Human Decision Processes* 50 (2): 179–211. doi:10.1016/0749-5978(91)90020-T

Alvarado, C., and N. Spring. 2018. "Successfully Engaging Early Undergraduates in CS Research." *Proceedings of the 49th ACM Technical Symposium on Computer science education - SIGCSE '18*, 1050. New York: ACM Press. doi:10.1145/3159450.3162365.

Ameen, K., S. H. Batool, and M. A. Naveed. 2018. "Difficulties Novice LIS Researchers Face While Formulating a Research Topic." *Information Development* 20 (10): 1–9. doi:10.1177/0266666918774875.

Baguley, T. 2009. "Standardized or Simple Effect Size: What Should be Reported?" *British Journal of Psychology* 100 (3): 603–17. doi:10.1348/000712608X377117.

Bahr, D. 2009. "A One Week Intensive Short Course for Introducing Lower Division Students to Undergraduate Research." *2009 ASEE Annual Conference and exposition*, Austin, TX, 14.81.1–14.81.7. American Society for Engineering Education. Retrieved from https://www.scopus.com/record/display.uri?eid=2-s2.0-85029037648&origin=resultslist&sort=plf-f&src=s&st1=%22research+based+learning%22&st2=%22research-based+learning%22&nlo=&nlr=&nls=&sid=f0a20a0d8a1008d23a77572667644e72&sot=b&sdt=cl&cluster=scopubyr,%252.

Baiduc, R. R., D. Drane, G. J. Beitel, and L. C. Flores. 2017. "A Research Preparatory Program for First-year College Students: Student Selection and Preparation Lead to Persistence in Research." *Innovative Higher Education* 42 (3): 269–84. doi:10.1007/s10755-016-9377-4.

Bandura, A. 1997. "Self-efficacy: Toward a Unifying Theory of Behavioral." *Psychological Review* 84 (2): 191–215. doi:10.1037/0033-295X.84.2.191.

Bandura, A. 2006. *Guide for Constructing Self-efficacy Scales*. Accessed February 6, 2016. https://www.uky.edu/~eushe2/Bandura/BanduraGuide2006.pdf.

Bloom, B., M. D. Engelhart, E. J. Furst, and D. R. Krathwohl. 1956. *Taxonomy of Educational Objectives: The Classification of Educational Goals Handbook 1 Cognitive Domain*. Longman Publishing Group. http://www.univpgri-palembang.ac.id/perpus-fkip/Perpustakaan/Pendidikan&Pengajaran/Taxonomy_of_Educational_Objectives__Handbook_1__Cognitive_Domain.pdf.

Boula, J., K. Morgan, C. Morrissey, and R. Shore. 2017. "How Do Students Understand New Ideas? In Response to the Deans for Impact Report (DFI)." *Journal of Applied Educational and Policy Research* 3 (1): 5–13. https://journals.uncc.edu/jaepr/article/view/649.

Brew, A. 2010. "Imperatives and Challenges in Integrating Teaching and Research." *Higher Education Research & Development* 29 (2): 139–50. doi:10.1080/07294360903552451.

Brew, A. 2013. "Understanding the Scope of Undergraduate Research: A Framework for Curricular and Pedagogical Decision-making." *Higher Education* 66 (5): 603–18. doi:10.1007/s10734-013-9624-x.

Brownell, S., M. Kloser, and T. Fukami. 2012. "Undergraduate Biology Lab Courses: Comparing the Impact of Traditionally Based "Cookbook" and Authentic Research-based Courses on Student Lab Experiences." *Journal of College Science Teaching* 41 (4): 36–45. https://cset.stanford.edu/sites/default/files/files/documents/publications/brownell-et-al-2012.pdf.

Brush, C., I. Duhaime, W. Gartner, A. Stewart, J. Katz, M. A. Hitt, and S. Venkataraman. 2003. "Doctoral Education in the Field of Entrepreneurship." *Journal of Management* 29 (29): 309–31.

Chang, Y., and C. J. Ramnanan. 2015. "A Review of Literature on Medical Students and Scholarly Research." *Academic Medicine* 90 (8): 1162–73. doi:10.1097/ACM.0000000000000702.

Chase, A., D. Pakhira, and M. Stains. 2013. "Implementing Process-oriented, Guided-inquiry Learning for the First Time: Adaptations and Short-term Impacts on Students' Attitude and Performance." *Journal of Chemical Education* 90 (4): 409–16. doi:10.1021/ed300181t.

Cheong, S., J. Reeve, and I. Moon. 2012. "Experimentally Based, Longitudinally Designed, Teacher-focused Intervention to Help Physical Education Teachers Be More Autonomy Supportive Toward Their Students." *Journal of Sport and Exercise Psychology* 34 (3): 365–96. doi:10.1123/jsep.34.3.365.

Colbert-White, E., and E. Simpson. 2017. "A Workbook for Scaffolding Mentored Undergraduate Research Experiences in the Social and Behavioral Sciences." *International Journal of Teaching and Learning in Higher Education* 29 (2): 309–80. http://www.isetl.org/ijtlhe/.

Cole, K. E., M. Inada, A. M. Smith, and M. P. Haaf. 2013. "Implementing a Grant Proposal Writing Exercise in Undergraduate Science Courses to Incorporate Real-world Applications and Critical Analysis of Current Literature." *Journal of Chemical Education* 90 (10): 1316–9. doi:10.1021/ed400130s.

Cortright, R. N., H. L. Lujan, A. J. Blumberg, J. H. Cox, and S. E. DiCarlo. 2013. "Higher Levels of Intrinsic Motivation are Related to Higher Levels of Class Performance for Male but not Female Students." *Advances in Physiology Education* 37 (3): 227–32. doi:10.1152/advan.00018.2013.

Cortright, R. N., H. L. Lujan, J. H. Cox, M. A. Cortright, B. M. Langworthy, L. M. Petta, and S. E. DiCarlo. 2015. "Intellectual Development is Positively Related to Intrinsic Motivation and Course Grades for Female but not Male Students." *Advances in Physiology Education* 39 (3): 181–6. doi:10.1152/advan.00117.2014.

Corwin, L. A., M. J. Graham, and E. L. Dolan. 2015. "Modeling Course-based Undergraduate Research Experiences: An Agenda for Future Research and Evaluation." *CBE—Life Sciences Education* 14 (1): 1–13. doi:10.1187/cbe.14-10-0167.

De Jong, T. 2010. "Cognitive Load Theory, Educational Research, and Instructional Design: Some Food for Thought." *Instructional Science* 38 (2): 105–34. doi:10.1007/s11251-009-9110-0.

Deci, E., and R. Ryan. 1982. *Selfdeterminationtheory.org – Intrinsic Motivation Inventory (IMI)*. http://selfdeterminationtheory.org/intrinsic-motivation-inventory/.

Deci, E., and R. Ryan. 2000. "Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-being." *American Psychologist* 55 (1): 68–78. doi:10.1037110003-066X.55.1.68.

Deci, E., and R. Ryan. 2012. "Motivation, Personality, and Development Within Embedded Social Contexts: An Overview of Self-determination Theory." In *The Oxford Handbook of Human Motivation*, 85–107. Oxford: Oxford University Press. https://books.google.be/books?hl=en&lr=&id=YU8lpnTnQasC&oi=fnd&pg=PT104&dq=Motivation,+personality+and+development+within+embedded+social+envirnonments&ots=5OHOCe1qiz&sig=PXzLY89OaEgVnkxi_pFGaJvyU04.

Firdaus, and Darmadi. 2017. "Shaping Scientific Attitude of Biology Education Students Through Research-Based Teaching." *4th International Conference on Research, Implementation, and Education of Mathematics and Sciences: Research for Education Developing Scientific Attitude in Sciences and Mathematics*, 1000041-100004-100005. doi:10.1063/1.4995214.

Follmer, D. J., S. E. Zappe, E. W. Gomez, and M. Kumar. 2015. "Preliminary Evaluation of a Research Experience for Undergraduates (REU) Program: A Methodology for Examining Student Outcomes." *ASEE Annual Conference and Exposition: Making Value for Society* (26.1243.1–26.1243.26). American Society for Engineering Education. https://www.scopus.com/record/display.uri?eid=2-s2.0-84941992664&origin=resultslist&sort=plf-f&src=s&st1=%22research+based+learning%22&st2=%22research-based+learning%22&nlo=&nlr=&nls=&sid=19c9360464f60f06bb476978d8ea95da&sot=b&sdt=cl&cluster=scopubyr,%252

Fuller, I. C., A. Mellor, and J. A. Entwistle. 2014. "Combining Research-based Student Fieldwork with Staff Research to Reinforce Teaching and Learning." *Journal of Geography in Higher Education* 38 (3): 383–400. doi:10.1080/03098265.2014.933403.

Gagne, M., J. Forest, M.-H. Gilbert, C. Aube, E. Morin, and A. Malorni. 2010. "The Motivation at Work Scale: Validation Evidence in Two Languages." *Educational and Psychological Measurement* 70 (4): 628–46. doi:10.1177/0013164409355698.

Griffiths, R. 2004. "Knowledge Production and the Research-teaching Nexus: The Case of the Built Environment Disciplines." *Studies in Higher Education* 29 (6): 709–26. doi:10.1080/0307507042000287212.

Guerin, C., and D. Ranasinghe. 2010. "Why I Wanted More: Inspirational Experiences of the Teaching–Research Nexus for Engineering Undergraduates." *Journal of University Teaching & Learning Practice* 7 (2): 1–22. http://ro.uow.edu.au/jutlp/vol7/iss2/8.

Hagger, M. S., S. Sultan, S. J. Hardcastle, and N. L. D. Chatzisarantis. 2015. "Perceived Autonomy Support and Autonomous Motivation Toward Mathematics Activities in Educational and out-of-School Contexts is Related to Mathematics Homework Behavior and Attainment." *Contemporary Educational Psychology* 41: 111–23. doi:10.1016/j.cedpsych.2014.12.002.

Healey, M. 2005. "Linking Research and Teaching to Benefit Student Learning." *Journal of Geography in Higher Education* 29 (2): 183–201. doi:10.1080/03098260500130387.

Healey, M., and A. Jenkins. 2009. *Linking Discipline-based Research and Teaching Through Mainstreaming Undergraduate Research and Inquiry*. Retrieved from http://resources.glos.ac.uk/ceal/.

Hill, M., L. Mann, and A. Wearing. 1995. "The Effects of Attitude, Subjective Norm and Self-efficacy on Intention to Benchmark: A Comparison Between Managers with Experience and No Experience in Benchmarking." *Journal of Organizational Behavior* 17: 313–27.

Horta, H., V. Dautel, and F. M. Veloso. 2012. "An Output Perspective on the Teaching–Research Nexus: an Analysis Focusing on the United States Higher Education System." *Studies in Higher Education* 37 (2): 171–87. doi:10.1080/03075079.2010.503268.

Howard, D. R., and J. A. Miskowski. 2005. "Using a Module-based Laboratory to Incorporate Inquiry Into a Large Cell Biology Course." *Cell Biology Education* 4 (3): 249–60. doi:10.1187/cbe.04-09-0052.

Jenkins, A., and M. Healey. 2010. "Undergraduate Research and International Initiatives to Link Teaching and Research." *CUR Quarterly* 30 (3): 36–42. http://m.alanjenkins.info/publications/spring10jenkins.pdf.

John, J., and J. Creighton. 2011. "Researcher Development: the Impact of Undergraduate Research Opportunity Programmes on Students in the UK." *Studies in Higher Education* 36 (7): 781–97. doi:10.1080/03075071003777708.

Jones, C. D. 2011. "The Kitchen Is Your Laboratory: A Research-based Term-paper Assignment in a Science Writing Course." *Journal of Chemical Education* 88 (8): 1062–8. doi:10.1021/ed1011184.

Joubert, L., L. Hebel, and A. McNeill. 2017. "Teaching Research in Social Work Through Academic Practitioner Partnerships: Knowledge, Competency and Confidence." *Advances in Social Work and Welfare Education* 19 (1): 37–47. https://search.informit.com.au/documentSummary;dn=054140172511792;res=IELHSS.

Jungmann, T., and P. Ossenberg. 2014. "Research Workshop in Engineering Education – Draft of New Learning." 2014 *IEEE Global engineering education Conference (EDUCON)*, 83–87. IEEE. doi:10.1109/EDUCON.2014.6826072.

Kirschner, P., J. Sweller, and R. Clark. 2006. "Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-based, Experiential, and Inquiry-based Teaching." *Educational Psychologist* 41 (2): 75–86. doi:10.1207/s15326985ep4102_1.

Lambert, C. 2009. "Pedagogies of Participation in Higher Education: A Case for Research-based Learning." *Pedagogy, Culture & Society* 17 (3): 295–309. doi:10.1080/14681360903194327.

Lehtinen, A., and J. Viiri. 2017. "Guidance Provided by Teacher and Simulation for Inquiry-based Learning: A Case Study." *Journal of Science Education and Technology* 26 (2): 193–206. doi:10.1007/s10956-016-9672-y.

Levy, P., and R. Petrulis. 2012. "How do First-year University Students Experience Inquiry and Research, and What are the Implications for the Practice of Inquiry-based Learning?" *Studies in Higher Education* 37 (1): 85–101. doi:10.1080/03075079.2010.499166.

McCarthy, G. 2015. "Motivating and Enabling Adult Learners to Develop Research Skills." *Australian Journal of Adult Learning* 55 (2): 309–30. http://eric.ed.gov/?q=research+skills&ft=on&id=EJ1068383.

McNamara, L. 2016. "Faculty Motivations: An Exploratory Study of Motivational Factors of Faculty to Assist with Students' Research Skills Development." In *Library and Information Science : Parameters and Perspectives*, 241–55. Boca Raton, FL: Apple Academic Press.

Morrison, B., B. Dorn, and M. Guzdial. 2014. "Measuring Cognitive Load in Introductory CS: Adaptation of an Instrument." *Proceedings of the Tenth Annual Conference on International Computing Education Research*, Glasgow, 131–8. doi:10.1145/2632320.2632348.

Myatt, P. 2012. "Student Perceptions of the Undergraduate Research Experience: What do They Think They Really Gain and How Much Influence Does it Have?" In *Proceedings of The Australian Conference on Science and Mathematics Education (formerly UniServe Science Conference)*, 85–90. Sydney, Australia.

Myers, J., A. Sawyer, K. Dredger, S. Barnes, and R. Wilson. 2018. "Examining Perspectives of Faculty and Students Engaging in Undergraduate Research." *Journal of the Scholarship of Teaching and Learning* 18 (1): 136–49. doi:10.14434/josotl.v18i1.22348.

Niemiec, C., and R. Richard. 2009. "Autonomy, Competence, and Relatedness in the Classroom." *Theory and Research in Education* 7 (2): 133–44. doi:10.1177/1477878509104318.

Paas, F., A. Renkl, and J. Sweller. 2004. "Cognitive Load Theory: Instructional Implications of the Interaction Between Information Structures and Cognitive Architecture." *Instructional Science* 32 (1–2): 1–8. https://link.springer.com/content/pdf/10.1023/B:TRUC.0000021806.17516.d0.pdf.

Paas, F., J. E. Tuovinen, H. Tabbers, and P. W. M. Van Gerven. 2003. "Cognitive Load Measurement as a Means to Advance Cognitive Load Theory." *Educational Psychologist* 38 (1): 63–71. doi:10.1207/S15326985EP3801_8.

Pittaway, L. 2009. "The Role of Inquiry-based Learning in Entrepreneurship Education." *Industry and Higher Education* 23 (3): 153–62. doi:10.5367/000000009788640251.

Popa, D., and B. C. Voicu. 2015. Motivational Aspects Engaged in Performance of Preadolescent Students. In *Procedia – Social and Behavioral Sciences*, Vol. 203, 186–91. Elsevier. doi:10.1016/j.sbspro.2015.08.280.

Roach, M. 2017. "Encouraging Entrepreneurship in University Labs: Research Activities, Research Outputs, and Early Doctorate Careers." *PloS ONE*, 12 (2): e0170444. doi:10.1371/journal.pone.0170444.

Rosenkranz, S., S. Wang, and W. Hu. 2015. "Motivating Medical Students to do Research: A Mixed Methods Study Using Self-determination Theory." *BMC Medical Education* 15 (1): 95–107. doi:10.1186/s12909-015-0379-1.

Russell, S., M. Hancock, and J. McCullough. 2017. *Benefits of Undergraduate Research Experiences*. Education Forum. doi:10.1126/science.1140384.

Ryan, E. 2016. "Undergraduate Nursing Students' Attitudes and use of Research and Evidence-based Practice – an Integrative Literature Review." *Journal of Clinical Nursing* 25 (11–12): 1548–56. doi:10.1111/jocn.13229.

Ryan, R., and E. Deci. 2000. "Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions." *Contemporary Educational Psychology* 25 (1): 54–67. doi:10.1006/ceps.1999.1020.

Sam, C., and P. van der Sijde. 2014. "Understanding the Concept of the Entrepreneurial University from the Perspective of Higher Education Models." *Higher Education* 68 (6): 891–908. doi:10.1007/s10734-014-9750-0.

Schlicht, J., and F. Klauser. 2014. "Improving Higher Education by Linking Research with Teaching and Learning Processes." *South African Journal of Higher* 28 (3): 1017–32. http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=10113487&AN=110022392&h=m5ODBjKL3ZJSlDHT%2F28TwbLaL3fOb6GyePgvLJGxIPplGJ37BV4O3KCmRQYRQWjobe6hHixr2UVRHEDQJ2KR4w%3D%3D&crl=c.

Schmeck, A., M. Opfermann, T. van Gog, F. Paas, and D. Leutner. 2015. "Measuring Cognitive Load with Subjective Rating Scales During Problem Solving: Differences Between Immediate and Delayed Ratings." *Instructional Science* 43 (1): 93–114. doi:10.1007/s11251-014-9328-3.

Schneider, M., and F. Preckel. 2017. "Variables Associated with Achievement in Higher Education: A Systematic Review of Meta-analyses." *Psychological Bulletin* 143 (6): 565–600. doi:10.1037/bul0000098.

Shaw, L., and D. Kennepohl. 2013. "Student and Faculty Outcomes of Undergraduate Science Research Projects by Geographically Dispersed Students." *The International Review of Research in Open and Distributed Learning* 14 (5): 70–81. doi:10.19173/irrodl.v14i5.1551.

Söderlind, J., and M. Magnell. 2015. "The Teaching-research Nexus in Engineering Education." *43rd Annual SEFI Conference*, Orleans, June 29–July 2.

Soltano, E., S. Meyer, and L. Larrivee. 2016. "Involving Students in Interdisciplinary Faculty Research Teams: Benefits and Limitations." *Currents in Teaching & Learning* 7 (2): 38–45. http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=19453043&AN=115005657&h=0ThDbOA0VqvGbODfuQPt%2Fh4mdDGVSIPprGvN5PUSlxodjk7DQeHRlevyzsjbf0tr2LhDeuMOw9cMAOOPxZ7doA%3D%3D&crl=c.

Sota, C., and K. Peltzer. 2017. "The Effectiveness of Research Based Learning Among Master Degree Student for Health Promotion and Preventable Disease, Faculty of Public Health, Khon Kaen University, Thailand." *Procedia – Social and behavioral Sciences*, 1359–65, Almeria. doi:10.1016/j.sbspro.2017.02.226.

Sweller, J. 2011. Cognitive Load Theory. In *Psychology of Learning and Motivation*, Vol. 55, 37–76. doi:10.1016/B978-0-12-387691-1.00002-8.

Sweller, J. 2015. "In Academe, What Is Learned, and How Is It Learned?" *Current Directions in Psychological Science* 24 (3): 190–94. doi:10.1177/0963721415569570.

Sweller, J. 2016. Cognitive Load Theory, Evolutionary Educational Psychology, and Instructional Design. In *Evolutionary Perspectives on Child Development and Education*, 291–306. Cham: Springer.

Sweller, J., J. Van Merrienboer, and F. Paas. 1998. "Cognitive Architecture and Instructional Design." *Educational Psychology Review* 10 (3): 251–96. doi:10.1023/a:1022193728205.

Tight, M. 2016. "Examining the Research/Teaching Nexus." *European Journal of Higher Education* 6 (4): 293–311. doi:10.1080/21568235.2016.1224674.

Tomasik, J. H., K. E. Cottone, M. T. Heethuis, and A. Mueller. 2013. "Development and Preliminary Impacts of the Implementation of an Authentic Research-based Experiment in General Chemistry." *Journal of Chemical Education* 90 (9): 1155–61. doi:10.1021/ed300328p.

Tomasik, J. H., D. LeCaptain, S. Murphy, M. Martin, R. M. Knight, M. A. Harke, and I. D. Acevedo-Polakovich. 2014. "Island Explorations: Discovering Effects of Environmental Research-based Lab Activities on Analytical Chemistry Students." *Journal of Chemical Education* 91 (11): 1887–94. doi:10.1021/ed5000313.

Walkington, H., A. Griffin, L. Keys-Mathews, S. Metoyer, W. Miller, and R. Baker. 2011. "Embedding Research-based Learning Early in the Undergraduate Geography Curriculum." *Journal of Geography in Higher Education* 35 (3): 315–30. doi:10.1080/03098265.2011.563377

Wiley, E. A., and N. A. Stover. 2014. "Immediate Dissemination of Student Discoveries to a Model Organism Database Enhances Classroom-based Research Experiences." *Cell Biology Education* 13 (1): 131–38. doi:10.1187/cbe.13-07-0140.

Willis, D. A., P. S. Krueger, and A. Kendrick. 2013. "The Influence of a Research Experiences for Undergraduates Program on Student Perceptions and Desire to Attend Graduate School." *Journal of STEM Education* 14 (2): 21–28.

Willison, J. W. 2012. "When Academics Integrate Research Skill Development in the Curriculum." *Higher Education Research & Development* 31 (6): 905–19. doi:10.1080/07294360.2012.658760.

Wilson, A., S. Howitt, P. Roberts, G. Åkerlind, and K. Wilson. 2013. "Connecting Expectations and Experiences of Students in a Research-immersive Degree." *Studies in Higher Education* 38 (10): 1562–76. doi:10.1080/03075079.2011.633163.

Wood, D. R. 2016. *The Impact of Students' Perceived Relatedness and Competence upon Their Motivated Engagement with Learning Activities: A Self-determination Theory Perspective*. University of Birmingham. http://etheses.bham.ac.uk/6627/1/Wood16PhD.pdf.